ORIGINAL RESEARCH

Impact of a Citywide Blackout on an Urban Emergency Medical Services System

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Abbreviations:
ACR = ambulance call report
ARD = assignment receiving dispatcher
CFR = certified first responder
EDT = Eastern Daylight Time
EMS = emergency medical services
FDNY = New York City Fire Department
NYC = New York City
OMA = Office of Medical Affairs
OOHCA = out-of-hospital cardiac arrest

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Abstract

Introduction: On 14 August 2003, New York City and a large portion of the northeastern United States experienced the largest blackout in the history of the country. An analysis of such a widespread disaster on emergency medical service (EMS) operations may assist in planning for and managing such disasters in the future.

Methods: A retrospective review of all EMS activity within New York City's 9-1-1 emergency telephone system during the 29 hours during which all or parts of the city were without power (4:11pm Eastern Daylight Time (EDT) on 14 August 2003 until 9:03pm EST on 15 August 2003) was performed. Control periods were established utilizing identical time periods during the five weeks preceding the blackout.

Results: Significant increases were identified in the overall EMS demand (7,844 incidents vs. 3,860 incidents; p <0.001) as well as in 20 of the 62 call-types of the system, including cardiac arrests (119 vs. 76, p = 0.043). Significant decreases were found only among calls related to psychological emergencies (114 vs. 221; p = 0.006) and drug- or alcohol-related emergencies (78 vs. 145.6; p = 0.009). Though median response times increased by only 60 seconds, median call-processing times within the 9-1-1 emergency telephone system EMS dispatch center of the city increased from 1.1 to 5.5 minutes.

Conclusions: The citywide blackout resulted in dramatic changes in the demands upon the EMS system of New York City, the types of patients for whom EMS providers were assigned to provide care, and the dispositions for those assignments. During this time of increased, system-wide demand, the use of cross-trained firefighter and first-responder engine companies resulted in improved response times to cardiac arrest patients. Finally, the ability of the EMS dispatch center to process the increased requests for EMS assistance proved to be the rate-limiting step in responding to these emergencies. These findings will prove useful in planning for future blackouts or any disaster that may broadly impact the infrastructure of a city.

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Introduction

At 16:11 hours (h) Eastern Daylight Time (EDT) on Thursday, 14 August 2003, much of the northeastern United States was in the midst of the largest blackout in US history. For the first time since 1977, all of New York City (NYC) was without electricity. This paper describes the system demands on the emergency medical services (EMS) system of NYC for the 29 hours that the city was without power.

Setting

According to 2000 US Census Bureau data, just over eight million people reside within the 300 square miles that comprise the five boroughs of NYC (Manhattan, Brooklyn, Queens, Staten Island, and the Bronx). The population increases during business hours to over 12 million with the largest concentration below 60^{th} Street in Manhattan, a <10 square mile area in which

Call Type	Response	Priority Level
ARREST (cardiac arrest)	ALS, BLS, CFR	1
CHOKE (choking)	ALS, BLS, CFR	1
DROWN (drowning)	ALS, BLS, CFR	2
ANAPH (anaphylaxis)	ALS, CFR	2
STATEP (status epilepticus)	ALS, CFR	2
UNC (unconscious)	ALS, CF	2
ASTHMA (asthmatic)	ALS	2
ASTHMC (critical asthmatic)	ALS, CFR	2
DIFFBR (difficulty breathing)	ALS	2
MEDVAC (aeromedical transfer)	ALS	2
TRAUMA (injury with entrapment)	BLS (and Rescue)	2
JUMPDN (fall)	BLS, CFR	2
VEMON (snake or spider bite)	BLS, CFR	2
CVAC (stroke with <2 hr onset)	BLS	2
OBCOMP (complicated pregnancy)	BLS	2
ALTMEN (altered mental status)	ALS	3
BURNMA (facial or >10% burn)	ALS, CFR	3
CARD (cardiac condition)	ALS, CFR	3
ELECT (electrical injury)	ALS, CFR	3
INBLED (GI bleed or shunt bleed)	ALS	3
AMPMAJ (any amputation except digit)	BLS, CFR	3
INJMAJ (impalement, CHI, massive bleed)	BLS,CFR	3
OBOUT (active delivery with crowning)	BLS, CFR	3
PEDSTR (pedestrian struck)	BLS (and Rescue)	3
GYNMAJ (vaginal bleed with orthostasis)	BLS	3
PD13C (confirmed police officer involved)	BLS	3
SHOT (gunshot)	BLS	3
STAB (stabbing)	BLS	3
CVA (possible CVA with >2 hrs duration)	BLS	4
DRUG (intoxication: alcohol or med)	BLS	4
FIRE75 (all hands fire)	BLS	4

Table 1—New York City Fire Department call type designations, response, and priority. The first 28 call types listed are those considered to be life-threatening for quality assurance activities within the department. Additional call types exist for mass casualty incidents (MCIs), with numeric designations based on the cause of the MCI, but are not listed here. ***(continued)***

over two million people work or reside. During 2002, 35 million visitors added the last layer to the city's dynamic population.

EMS System

The NYC EMS system is comprised of four entities: (1) the New York City Fire Department (FDNY); (2) voluntary hospital ambulance services; (3) commercial ambulance services; and (4) volunteer ambulance corps. *Voluntary hospital ambulance services* are formed by existing hospitals in NYC who contract with the FDNY to operate ambulances that are incorporated into the 9-1-1 system. All activity within the 9-1-1 emergency telephone system is only assigned to FDNY ambulances, which account for nearly 60% of the units, or participating 9-1-1 emergency phone system voluntary hospital ambulances. Working eight hour ambulance shifts, these two entities provide >900 tours on an average day, with a maximum of 396 ambulances in service at any one time. Responding to an average of 3,476 responses per day during 2002, that year the system provided >500,000 responses to calls classified as potential threats to life or limb, including >24,000 responses to cardiac/respiratory arrest calls.[1]

Calls to the 9-1-1 emergency telephone system in NYC are answered by police department assignment receiving dispatchers (ARDs). Those callers in need of medical assistance are transferred to ARDs at a separate FDNY location that houses the EMS Communications Center. Following an algorithmic dispatch matrix developed by the FDNY, the ARDs then assign one of 62 call-types (Table 1) that dictate the priority of the calls and the assignment of any combination of three EMS/fire department resources: (1) fire department engines; (2) basic life support (BLS) units; and (3) advanced life support (ALS) units.

Fire department engines are staffed with at least two certified first responders (CFRs) trained in basic cardiopulmonary resuscitation, automated defibrillation, and first aid. Basic life support ambulances are staffed with two emergency medical technicians (EMTs) trained in basic airway management, basic wound care, and limited medication administration. Advanced life support ambulances are staffed with two paramedics trained in advanced airway management (including endotracheal intubation), manual defibrillation, cardiac rhythm interpretation, intravenous access and drug administration, and other advanced skills.

Medical direction and oversight for the 9-1-1 emergency telephone system are the responsibility of the FDNY Office of Medical Affairs (OMA), employing five full-time EMS physicians. In addition to daily activities within OMA and their respective EMS divisions, a rotating call schedule provides for one of the five physicians to be on call for each 24-hour periods for citywide field response and issues requiring immediate administrative action.

Methods

A review of EMS operations from 16:11 h EDT on Thursday, 14 August 2003 until 21:03 h EST on Friday, 15 August 2003 was performed in order to analyze the impact that the citywide loss of power had on EMS demand and performance. This time frame corresponds to the time at which power was lost throughout the city until the time

Call Type	Response	Priority Level
HEAT (heat-related emergency)	BLS	4
MVAINJ (confirmed injury, not entrapped)	BLS	4
RESPIR (upper respiratory infection)	BLS	4
OBMIS (vaginal bleeding, < 24wks)	BLS	4
SICPED (sick child, 1-5 years old)	BLS	4
ABDPN (abdominal pain)	BLS	5
AMPMIN (amputation of digit)	BLS	5
COLD (cold-related emergency)	BLS	5
GYNHEM (vaginal bleed, no orthostasis)	BLS	5
HYPTN (nontraumatic bleed & HTN)	BLS	5
INHALE (toxic fumes or gas)	BLS	5
INJURY (isolated joint injury)	BLS	5
OBLAB (active labor >24 wks)	BLS	5
MEDRXN (allergy, only derm complaint)	BLS	5
CHILDA (child abuse)	BLS	6
MVA (motor vehicle accident with no confirmed injuries)	BLS	6
OTHER (unable to otherwise classify)	BLS	6
RAPE (rape, no higher priority complaint)	BLS	6
SEIZR (uncomplicated/ unwitnessed)	BLS	6
SICK (minor physical ailments)	BLS	6
BURNMI (<10% burn)	BLS	7
DOA (body parts or floating corpse)	BLS	7
EDP (emotionally disturbed patient)	BLS	7
INJMIN (isolated extremity injury)	BLS	7
JUMPUP (threatening to jump)	BLS	7
PD13 (unconfirmed police officer involved)	BLS	7
SICMIN (general malaise)	BLS	7
SPEVNT (special event coverage)	BLS	8
STNDBY (fire with no injuries)	BLS	8
STRANS (interfacility transport)	BLS	8
DDOA (confirmed death)	BLS	9

Table 1—*(continued from page 429)* New York City Fire Department call type designations, response, and priority. The first 28 call types listed are those considered to be life-threatening for quality assurance activities within the department. Additional call types exist for mass-casualty incidents (MCIs), with numeric designations based on the cause of the MCI, but are not listed here.

when the last area within the city had power restored. Historical controls were established by utilizing an identical time periods for each of the five weeks prior to the blackout. The numbers derived from this analysis do not include fire-based CFR responses, but only ambulance and supervisory EMS responses.

A retrospective review was performed using the computer-aided dispatch (CAD) system, the FDNY data warehouse, and individual ambulance call reports (ACRs) analysis. Data were entered into Microsoft Excel spreadsheets for analysis by SPSS 11.0. (SPSS Inc., Chicago, IL) Individual call-type analyses were performed using a Student's t-test with presumed equal variance. Significance was determined by a p-value of <0.05.

Results

Call Volume and Types

The mean value for call volume during the control periods was 3,860 ±97 (one day) EMS incidents (standard deviation. During the blackout, the NYC 9-1-1 emergency telephone system provided EMS responses to 7,844 EMS incidents/day, a statistically significant increase when compared to the historical control periods (p <0.001). High priority call-types (Priority 1–3, Table 1), which comprised 33.6% of the total EMS incidents during the historical control periods, increased to 46.7% of the total volume during the blackout. The overall EMS volume is described in Table 2, which only lists those call-types that increased during the blackout. Of these, 20 call-types increased significantly.

The hourly EMS volume during the blackout as compared to the control periods as plotted in Figure 1. Call volumes increased at the time that power was lost and peaked 6 hours into the blackout. The level of demand remained above the five control periods until the conclusion of the blackout, at which time it returned to the level noted in historical controls.

Given the statistically significant increase in the number of patients with gunshot wounds (Table 2), further analysis was performed to define the volume of calls to which EMS responded that could be associated with violence or violent crimes. The changes in the number of gunshot and stabbing victims, rape, and child abuse cases, to which EMS responded are listed in Table 3. Only the number of calls related to gunshot wounds increased significantly.

Only two call-types decreased significantly during the blackout. The number of alcohol or drug-related call-types dropped from an average of 146 during the control periods to 78 incidents during the blackout (p = 0.009). Similarly, the number of emotionally disturbed patient call-types decreased from an average of 221 incidents to 114 during the blackout (p = 0.006).

System Performance Indicators

Response Times—Both unit and system response times to EMS calls during the control periods and the blackout were analyzed. During the control periods, the median unit response time (the elapsed time from the unit assigned to unit arriving on scene) was 5.9 min (interquartile range = 3.9–8.3 min) compared to the median unit response time

Call Type	Control Incidents	Blackout Incidents	*p*
DIFFBR (difficulty breathing)	302.8	1,790	<0.001
OTHER (unable to otherwise classify)	151.4	965	<0.001
INJURY (isolated joint injury)	676.0	960	<0.001
CARD (cardiac condition)	132.8	384	<0.001
ASTHMC (critical asthmatic)	67.6	225	<0.001
RESPIR (upper respiratory infection)	53.8	139	<0.001
ASTHMA (asthmatic)	25.6	135	<0.001
SEIZR (uncomplicated/unwitnessed)	60.2	117	<0.001
FIRE75 (all hands fire)	7.8	65	<0.001
HEAT (heat-related emergency)	3.25	43	<0.001
SICK (minor physical ailments)	537.6	897	0.001
SICKPED (sick child, 1-5 years old)	31.2	62	0.002
OBLAB (active labor >24 wks)	41.8	102	0.002
UNC (unconscious)	248.2	468	0.003
OBOUT (active delivery with crowning)	1.25	5	0.007
SHOT (gunshot)	27.0	49	0.017
INJMIN (isolated extremity injury)	71.2	134	0.022
SICMIN (general malaise)	8.6	27	0.038
ARREST (cardiac arrest)	76.2	119	0.043
JUMPDN (fall)	4.8	15	0.047
BURNMI (<10% burn)	4.0	11	0.066
INHALE (toxic fumes or gas)	4.4	10	0.080
BURNMA (facial or >10% burn)	7.0	13	0.098
ANAPH (anaphylaxis)	15.0	22	0.100
INJMAJ (impalement, CHI, massive bleed)	29.2	42	0.189
PEDSTR (pedestrian struck)	123.8	158	0.273
CVA (possible CVA with >2hrs duration)	16.0	22	0.293
ALTMEN (altered mental status)	49.6	58	0.309
OBCOMP (complicated pregnancy)	21.2	25	0.328
CHOKE (choking)	12.4	20	0.336
INBLED (GI bleed or shunt bleed)	30.0	35	0.365
DROWN (drowning)	2.4	4	0.390
OBMIS (vaginal bleeding, <24wks)	12.6	17	0.428
MEDRXN (allergy, only derm complaint)	6.0	8	0.541
PD13 (unconfirmed police officer involved)	11.6	14	0.593
STAB (stabbing)	25.8	26	0.965

Table 2—Raw numeric increases in EMS incidents as seen during the blackout and the historical control periods. Call-types not listed remained static or decreased during the blackout. (CVA = cerebrovascular accident; GI = gastrointestinal)

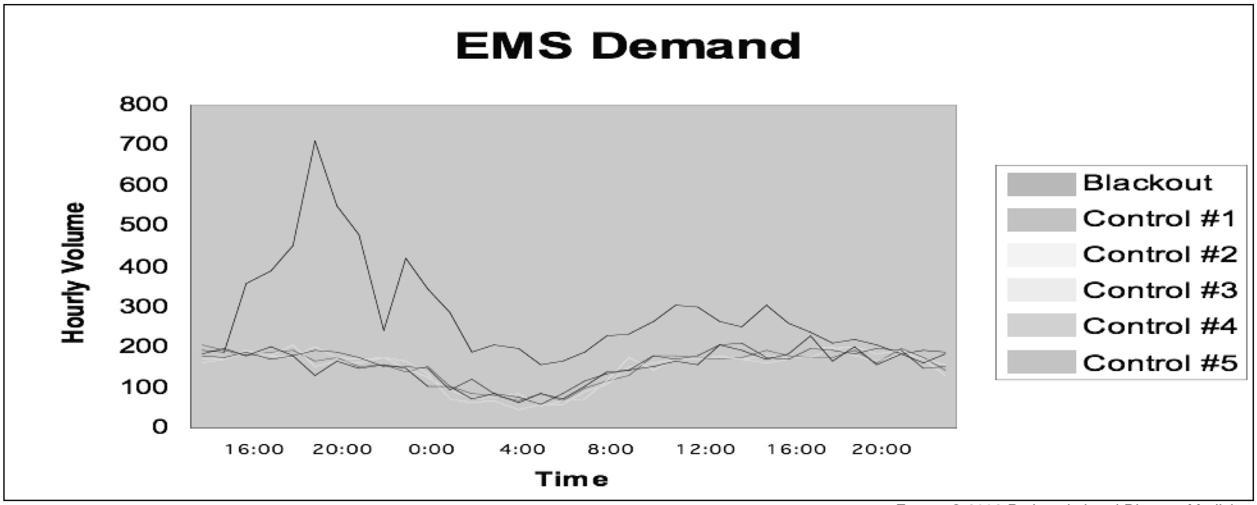

Figure 1—Comparison of the hourly call volumes for New York City emergency medical services system during the 2003 blackout as compared to five historical control periods, beginning two hours prior to and continuing through two hours after the blackout

Call-Type	Control	Blackout	*p*
SHOT	27.0	49	0.017
STAB	25.8	26	0.965
RAPE	7.4	5	0.350
CHILDA	1.75	0	NA

Table 3—Violence-related call-types, comparing the average from the five historical controls to the 2003 blackout (NA = not applicable)

during the blackout of 6.9 min (interquartile range = 4.1–10.3). The system response time (elapsed time from the call received by the 9-1-1 emergency telephone system to arrival of the unit on scene) also increased during the blackout, from a median system response time of 6.9 min during the control periods (interquartile range = 4.9–9.9) to a median time of 12.4 min during the blackout (interquartile range = 7.2–25.1).

The median unit response times during the control periods and the blackout are demonstrated in Figure 2; the median system processing times (elapsed time from the EMS receipt of the 9-1-1 call to the arrival of the unit) during the same periods is plotted in Figure 3.

Cardiac Arrest—System data were examined for all 9-1-1 emergency telephone system cardiac arrest responses during the blackout. The number of cardiac arrests increased from an average of 76 during the control periods to 119 during the blackout ($p = 0.043$) (Table 2). Response time analysis of these cases was limited to those calls that were known to be in response to cardiac arrest victims at the time of unit assignment. Therefore, only those calls that initially were dispatched as cardiac arrests during the control periods were included. Of the blackout cases, 17 of the 119 cardiac arrests (14%) were excluded because they initially were dispatched as lower priority call-types and subsequently upgraded to cardiac arrests following the arrival of the first EMS unit. Also excluded were an additional 12 (10%) blackout calls for which units were "flagged-down" by bystanders. These cases had no effective response time, as assignment and arrival were simultaneous. There were no cases of "flagged" cardiac arrest response during the control periods.

For the remaining 90 blackout cases, the mean system response for cardiac arrests (elapsed time from when the call was received to arrival of the first unit on-scene) of 8.2 min exceeded the mean response time of 5.2 min to known cardiac arrests during the control periods. Certified first-responder (CFR) engine companies were dispatched 28.9% of the time and arrived on-scene first in 17.8% of the cardiac arrest cases. In the subgroup in which the CFR was the first arriving unit on scene, a mean value for reduction in response time was 2.5 min. For known cardiac arrest cases during the historical control periods, CFR companies were dispatched 80.4% of the time and arrived first on-scene in 41.5% of known cardiac arrest cases, with a median reduction of response times to this latter group of 1.3 min.

During the control periods, an average of 40 ±7.2 patients were pronounced dead at the scene; the remainder were transported to the hospital for further management. During the blackout, 41 were pronounced dead at the scene ($p = 0.456$).

Patient Disposition—All EMS responses that resulted in patient transport were analyzed to determine the impact that the high EMS system call volume may have had on receiving emergency departments. While the system average was 2,821 ±85.8 transports during the control periods, the volume of EMS calls during the blackout resulted in a 28.4% increase in the number of patients transported to local emergency departments (total = 3,622, p <0.001). During the control periods, an average of 632 patients were unable to be located by the responding EMS crews, with a mean

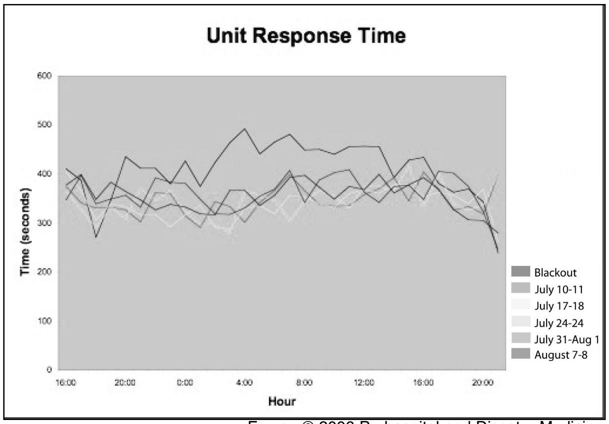

Figure 2—Median hourly intervals from the assignment of an emergency medical services unit to an assignment until the arrival of that unit at the assignment location

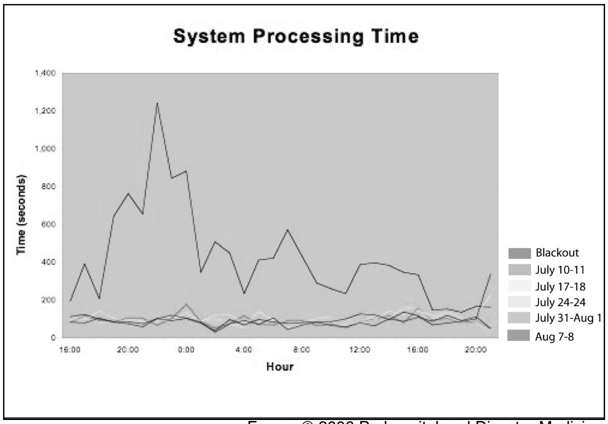

Figure 3—Median hourly intervals from the receipt of the 9-1-1 system call until the assignment of an emergency medical services unit to that incident

response time of 8.0 ±5.2 min. During the blackout, this number increased to 1,744 cases with a mean response time of 47.2 ±77.5 min. The differences in the number of such dispositions and the response times were statistically significant (p <0.001).

Discussion

Despite the recent attention to disaster preparedness, there is little in the medical literature that characterizes the system-wide impact of power failures.[2–4] In particular, a review of the literature found no focused and/or detailed description of the impact of such an event on EMS systems. While textbooks describe less common events such as floods, tidal waves, and volcanic eruptions, these sources do not address blackouts or power failures.[5,6] This study details the experience of a large, urban EMS system during the 2003 blackout in the Northeastern United States.

Several critical system issues were identified while reviewing the experiences of the NYC EMS system during this blackout—issues that would be important for any prehospital system to anticipate in planning for such events. In particular, it is important to note the significant increase in EMS demand, the changes in the types of emergencies, the increase in EMS response times and call processing times, and the changes in patient disposition.

The demands on the EMS system resulted in a 103% increase in EMS call volume during the 29-hour duration of the blackout when compared to the control periods. This increase could be attributed to several factors that would be common to this type of area-wide emergency. The blackout occurred in the midst of a summer workday, leaving millions of residents and commuters with no subway transportation or without access to their vehicles, including those parked in power-operated, stacked parking facilities or elevator-accessed carports. Even after people walked to their homes, they found air conditioning systems and elevators incapacitated, this being particularly notable in a city in which many buildings have a substantial vertical height.

This could have contributed to the increase in the number of exertion-induced types of medical emergencies, such as cardiac and respiratory complaints. The loss of air conditioning and increased physical demands may have contributed to the increase in heat-related and other medical call types observed during this periods. Additionally, it is possible that the use of alternative light sources, such as candles, caused the increase in EMS calls that resulted from structure fires.

Twenty of the system's 62 call-types recorded a significant increase during the blackout, including general medical problems such as sick children. It is not clear whether there was an increased frequency of these illnesses during this time period or whether increased EMS utilization reflected the loss of other means of transportation during the citywide blackout. The end result, in either case, was the increased utilization of emergency services and the need for additional resources to meet that need.

It has been reported that both the Overall Crime Index for NYC and the number of police arrests were less than during the same time during the previous year and "an average Thursday night," respectively.[7] Yet the EMS system experienced an significant increase in the number of requests for an EMS response for injuries involving gunshot wounds. Interestingly, the number of drug-related EMS calls and the number of emotionally disturbed individuals for whom EMS was called during this time decreased—a phenomenon that cannot completely be explained.

In addition to the demand placed on the system by the large volume of 9-1-1 emergency telephone system calls and EMS responses, the loss of power within the City resulted in physical obstacles caused by 11,000 traffic signals that were non-operational. Furthermore, the loss of power and resultant loss of the subway system came just prior to the end of the workday, maximizing the number of travelers who subsequently became pedestrians. With tens of thousands of people exiting the city on foot over the roadways, and in particular, bridges, this may have led to further slowdowns of the existing vehicular traffic, including emergency responses.

Partially, as a result of these physical obstacles, the time required for an assigned ambulance to arrive at the scene of an emergency increased by an average of one minute during the blackout. As shown in Figure 2, this was the result of increased unit response times during 19 of the 29 hours of the blackout when compared to the median times during the control periods.

The greater delay in providing EMS resources arose when dispatching units. As seen in Figures 1 and 3, call volumes that exceeded the mean volume of the control periods resulted in significant delays in the call processing times. Median call processing times rose from 1.1 min to 5.5 min, demonstrating the limited surge capacity of EMS communications centers and the need for such entities to be able to adjust their operations and staffing during such events.

The EMS response times are one factor cited as impacting the cardiac arrest survival rate in this city.[8] In NYC, fire services, trained and equipped with automated defibrillators, respond to many of the high priority call-types in an attempt to reduce the response time to critically ill or injured patients. Due to the large number of fire-related responses and rescue operations (persons trapped in elevators, subways, etc), CFR units were assigned to only 28.9% of all cardiac arrests during the blackout, and were the first responders to arrive on-scene in only 17.8% of these cases. Nevertheless, CFR units reduced response time by over two min in those arrests where they arrived on-scene first. The survival benefits associated with the early arrival of EMS in out-of-hospital cardiac arrest (OOHCA) are well established. Thus, the potential role of first responders in reducing response time is of critical importance given the demonstrated increase in OOHCA during this event.

Finally, 9-1-1 emergency telephone system-receiving hospitals need to be prepared for the increased number of patients and greater acuity of illness for patients transported to local emergency departments. In addition to the increase in the volume, the loss of EMS communications both within the agency and at the online medical control site resulted in fewer patients who were able to refuse transportation after consulting with an online medical control physician, as stipulated under current system protocol. When these two factors are combined with the loss of power and telephone services that left people without alternative choices that they typically might seek out, such as contacting their regular physician or relying on family members or other means of transportation by which to reach a healthcare facility, the result was an increased demand on both the EMS system and the receiving emergency departments.

Conclusion

This study has reviewed the experience of the NYC EMS system during the blackout of 14–15 August 2003. In doing so, areas of increased system demand have been identified that may help other municipalities to prepare for such an event. These are not system changes that would be unique to blackouts, but which might be extrapolated to any event with the potential to severely compromise the local infrastructure. Preparing for these events can help minimize the impact that disasters can have on the local population and the prehospital systems that serve them.

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